Laptops in the Engineering and Science Classroom

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Abstract

On the conference homepage a number of questions are raised, which I will answer in this brief based on my experiences with the Pilot Laptop Program of the College of Engineering and Science at Clemson University.

I. Introduction

Beginning in the fall of 1998, I co-initiated, with Associate Dean Steve Melsheimer, the College of Engineering and Science Pilot Laptop Program. The Pilot Program ran for four years and offered courses in calculus, differential equations, chemistry, physics, English composition, technical writing, history, computer science, and freshman engineering. About 120 students voluntarily participated each year. Beginning in the fall of 2002, the College of Engineering and Science and the College of Business and Behavioral Sciences will begin a laptop ownership requirement and a faculty development program for laptop instructors. It is anticipated that the College of Architecture, Arts, and Humanities will add a laptop requirement beginning in the fall of 2003 and the remaining two colleges will add a laptop requirement that year or the next.

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The infrastructure for the Pilot Program consisted of 15 renovated smart classrooms with electronic lecterns, LCD projectors, and wired network connections at the student tables. The program was supported by a central help desk and repair center that offered loaner laptops and repair by vendor-trained technicians. In addition, the course management system WebCT was made available to all instructors at Clemson.

During the 2001-2002 academic year Clemson added a wireless segment to the campus network, which covered the library and the student center. For the fall of 2002, the wireless segment of the campus network will be extended to the 50+ smart classrooms and a number of commons areas.

The College of Engineering and Science is part of the eight university SUCCEED coalition formed for the purpose of improving engineering education and sponsored by the National Science Foundation. During the Pilot Program, I used the excellent SUCCEED teaching effectiveness materials in a two-day laptop faculty development workshop. Beginning in the summer of 2002, Clemson will offer a university-wide laptop faculty development program. SUCCEED, the Clemson Provost Innovation Fund, and the College of Engineering and Science cosponsored the Pilot Program and WebCT.

For the Pilot Program, I developed non-traditional calculus III and differential equations courses using Maple and WebCT. These courses combined mini-lectures with problem sessions. In the fall of 2002, I will introduce a linear algebra course based on the Linear Algebra Modules Project, which will be entirely based on modules written as Maple worksheets.

Conclusions drawn from the Pilot Program include the following:

- the laptop environment proved pedagogically advantageous in many but not all, courses; some subjects are more difficult to adapt to laptops, but instructor skills are also a factor;
- a course management system provides a beneficial communication center for courses.;
- at the end of the freshman year, laptop students have a much richer computer skill set than a similar group of non-laptop classmates and a slightly higher grade point average;
- in a laptop classroom, students, or teams, can participate in a number of beneficial technology based active learning activities.; and
- the peer instruction component of team projects improves learning outcomes.

On the conference homepage a number of questions are raised, which I will now answer based on our experiences with the Pilot Laptop Program.

II. Question One

What new skills and experiences are students expected to bring to this learning environment?

There were no computer skill requirements for the freshmen entering the Pilot Laptop Program. This program attracted a cross-section of students with a broad range of computer skills. We used workshops several days before the start of the fall semester to give students the basics of logging into the network, sending and receiving e-mail, creating a Web page, and entering an on-line WebCT course. Our surveys indicated that by the end of the first year, the laptop students had a much richer skill set than a similar group of their non-laptop classmates. We attribute this gain primarily to peer instruction. Laptop students often worked in teams and shared their computer expertise. Some of these students said that they had no computer skills before coming to Clemson and were in fact afraid of computers. Instructors wishing to introduce students to new computer applications stated that having the laptops in the classroom greatly shortened the time required to bring students up to speed. This was especially true in courses that had a heavy computational component but no lab.

III. Question Two

How should both learners and e-technologies be measured, evaluated, and assessed?

A traditional college course might typically assess student performance using two to four hour exams and a final exam. Our laptop courses were non-traditional in the sense that they did not rely entirely on lectures and included both summative and formative methods of assessment. Summative assessment methods included hour exams and a final exam, individual and team projects, on-line quizzes, in-class quizzes, and individual and team graded problem sessions and homework. Formative assessment methods included on-line quizzes in preparation for class discussions, in-class individual and team problem sessions, minute-papers on muddy points, think-pair-share, on-line surveys, and student polling. Course software was used in many of these assessment methods. Formative assessment methods were used to adjust the course pace. Committed students were a good source of information about what was working and not working in the courses. On-line anonymous surveys, minute-papers, and course discussion boards were used to determine the effectiveness of the technologies being used.

IV. Question Three

What are effective ways to use e-technologies to enable laboratory work?

In laptop courses with a lab component that only require a networked computer, the lecture and lab begin to overlap. In lab courses using a range of equipment, data can be collected using laptops, lab notes can be taken, and students can make entries in collaborative on-line lab notebooks. An on-line collaborative lab notebook can provide an asynchronous method for peer editing of the final lab report. Using laptops, lecture courses that have a computer component but no formal lab can add computer exercises to the list of class activities. This is an effective way to introduce students to course software in such courses.

V. Question Four

What kinds of collaboration tools enhance team-oriented or project-based learning?

Course collaboration tools include a threaded discussion board, a calendar allowing both private and public entries, chat rooms, a whiteboard, team file sharing area, private team discussion board, team and individual presentation area, peer editing, e-mail, instant messaging, audio conferencing, and video conferencing. Many of these tools are provided in course or learning management systems.

VI. Question Five

What personnel and technical infrastructures work best in support of users of e-technologies?

The Pilot Laptop Program benefited from a high-end wired network, which includes the dorms, and an expanding wireless network. Soon student will be on-line from every corner of the campus. The heart of the Pilot Laptop Program was the central help desk and repair center. For the program to be effective, laptop down-time must be minimized. Essential personnel included the help desk manager, the repair center manager, and the faculty development coordinator. Technically proficient undergraduates were used to provide technical assistance to laptop faculty and graduate students were used to man the help desk and repair center. Today, it is possible to purchase in volume a 1+ GHz laptop with 14.1" screen, 256 MB of RAM, 30+ GB hard disk, CDRW/DVD, modem, wired and wireless network interfaces for less than $1800 US. The challenge is to provide laptop students with a software subscription package at a reasonable cost.

VII. Question Six

What are the critical enhancers and barriers for the creation and deployment of new e-technologies?

The cost of deployment is often cited as a barrier, but Marian Moore, Vice Chancellor at the University of North Carolina, Chapel Hill, argues that the Carolina Computing Initiative (laptops for students and laptops or desktops for instructors) will be a long term cost saver because the university will only need to support a few high-end labs and support of a standard platform will be centralized. A major barrier to the deployment of a laptop program is the cost of a software subscription package for use on student owned computers.

Perhaps the most critical factor to the success of a laptop course is the instructor's approach to teaching. Laptops are most effective in courses in which active learning activities are combined with mini-lectures. Since many of today's instructors use more traditional approaches, we are facing a considerable faculty development effort. Laptops, or technology in general, cannot turn bad teaching into good teaching. Clemson laptop instructors who set aside the traditional lecture mode of instruction and built courses around active learning activities were the most successful. Particularly notable success stories in this regard were our English composition courses, particularly the courses taught by Barbara Weaver. Here are some comments.

"In my position here as the Pilot Laptop Program Manager, I [Laurie Sherrod] speak with students regularly. When I ask how their classes are going, they nearly all mention Barbara Weaver's classes and the creative work that she is doing with them. It is especially amazing to me that these students — who all have a major in the College of Engineering and Science — are telling me that an English class is their favorite! Many of them say that English was their worst subject in high school."

Laptop student Betsy Beach writes. "I had Professor Weaver during the fall of my freshman year. I have always disliked English, partly because I am not a very good writer but she somehow changed my opinion on the subject. She helped me learn to improve my writing and appreciate English in general. My mom is an English teacher and could not believe how much my writing improved during that semester!"

VIII. Question Seven

How will e-technologies impact certification and accreditation of engineering education programs?

Engineering curricula are dominated by problem solving and design. The traditional approach is restricted to hand computations, which limits the complexity of the problems that can be addressed. Computer use has become integral to many courses, especially senior design, but the greater availability of technology provided by laptops will create higher expectations for "real-world" problems being brought into the classroom even at lower levels. Of course, there are also issues for "fully on-line" courses, whether for on-campus students or distance education students, but our laptop program has not involved this situation.

IX. Question Eight

What are effective ways to leverage interactions within the international engineering education community to produce better electronic technology-based environments and materials?

The SUCCEED coalition offers a model for collaboration in engineering education over a ten year period (see <http://www.succeednow.org>). Funding should be provided to instructors or teams of instructors to design, test, and publish their findings on courses using active learning with technology.

An important vehicle for sharing courseware that is developed is the use of course management systems such as WebCT and Blackboard. These facilitate development and sharing of content modules and homework and quiz question banks. Currently, the vendors in partnership with publishers are marketing "e-packs" for courses, but to date very little is available in engineering. By contrast, a number of "e-packs" are available for elementary courses in chemistry, physics, and mathematics.

Author's Biography

William F. Moss is a Professor of Mathematical Sciences at Clemson University. He has a BS in Electrical Engineering from MIT and a Ph.D. in Mathematics from the University of Delaware. He has worked at Lockheed Aircraft, the Naval Nuclear Power School, Georgia Institute of Technology, Old Dominion University, and Clemson University. His research involves mathematical modeling and the use of technology to improve learning outcomes.